

Report on Doppler Shift Experiment

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Description

This experiment consists of a spectrometer observing an exoplanet. The relatively stationary observer will see that the absorption spectra for the exoplanet differ when it is moving towards and away from them.

How to use it

The angular velocity of the planet is set using the slider at the bottom of the window. The absorption spectra for the exoplanet are shown above the slider. When the slider is moved so the angular velocity isn't 0, the absorption spectra will begin to shift.

There is also a plot of the emission spectra for the exoplanet which can be opened by checking the "Show emission plot" checkbox at the bottom of the window.

How it works

Variables

- a is the angle of rotation of the exoplanet from the northern position.
- r , $r2$ are the radius of the path travelled by the exoplanet and the radius of the path travelled by the star it orbits respectively.
- x , y are the x and y coordinates of the exoplanet. These coordinates are determined from the angle of the planet, a , and the radius of the path travelled by the exoplanet, r .
- vx , vy are the velocity of the exoplanet in the x and y axes respectively. They are also calculated from the angle of the planet, as well as the angular velocity of the system, ω .
- t is the time variable for the evolution of the system.
- off is the offset added to the position of the star-planet system to move it to the right of the spectrometer image.
- $segment$ is the two-dimensional array of coordinates for the absorption lines.
- $posRef$ is the array of positions of the absorption lines before the Doppler shift is applied.

- *offset* is the amount which the position of the absorption lines should be offset by the Doppler shift caused by the motion of the planet.
- *x2*, *y2* are the x and y positions of the star.
- *omega* is the angular velocity of both the exoplanet and the star.

Plotting Variables

- *xPoints*, *yPoints* are the arrays of coordinates for the points to plot on the emission spectrum plot.
- *waveOffset* is the amount which the wavelengths of the emission lines should be shifted due to the Doppler effect.
- *showPlot* is the variable behind the “Show Emission Plot” checkbox.
- *lamRef* is the array of x-coordinates for the points on the graph not considering the Doppler shift.

Initialisation

In the initialisation, an array of four random wavelengths between 400nm and 700nm are randomly generated and used to populate the arrays, *xPoints* and *lamRef*. They are given a corresponding value in *yPoints* between 0 and 0.2. Then, ten points from the array are randomly chosen as the absorption spectra and these points are given corresponding y-coordinates with values between 0.2 and 1. These wavelengths are then scaled down to values between -1 and 1 for use plotting the absorption lines on the spectrum of visible light. These are used to populate the two-dimensional array, *segment*, where the second dimension is the y-coordinate, -1 in order to place the lines at the bottom of the screen.

Evolution

Evol Page

The first evolution page introduces the relationship between the angle of rotation, *a*, and the angular velocity, *omega*.

Spectra

For each step of the evolution of the system, this page sets the positions and the points of the spectral lines equal to their reference values plus the appropriate Doppler shift.

Fixed relations

The fixed relations page contains relationships generating x and y coordinates and velocities from the angle of the planet and star. It also generates the offset for the positions and wavelengths of the absorption spectra based on the magnitude of the velocity in the x-axis.

Custom

- *positionToWavelength* takes a position on the spectrum between -1 and 1 and converts it to the equivalent wavelength in nanometers (between 400nm and 700nm) for plotting on the graph.
- *wavelengthToPosition* does the opposite of the *positionToWavelength* method.
- *randomPosition* generates a random value between -1 and 1 to be used as a position for an absorption line.

UI

Frames

The UI of this experiment consists of two windows: the simulation window and the plotting window. The plotting window is hidden by default and is opened with the “Show emission plot” checkbox at the bottom of the simulation window.

The simulation window contains the model exoplanet orbiting a star, showing their paths. It also shows the absorption lines for the exoplanet plotted on the spectrum of visible light. It has a slider at the bottom to change the angular velocity of the planet, as well as the play/pause button, the reset button and the checkbox to show the emission spectrum plot.

Images

This simulation makes use of two images. A drawing of a telescope, to act as a mock spectrometer, and a picture of the spectrum of visible light, to be the background for the spectral lines. Both of these images are freely licensed.

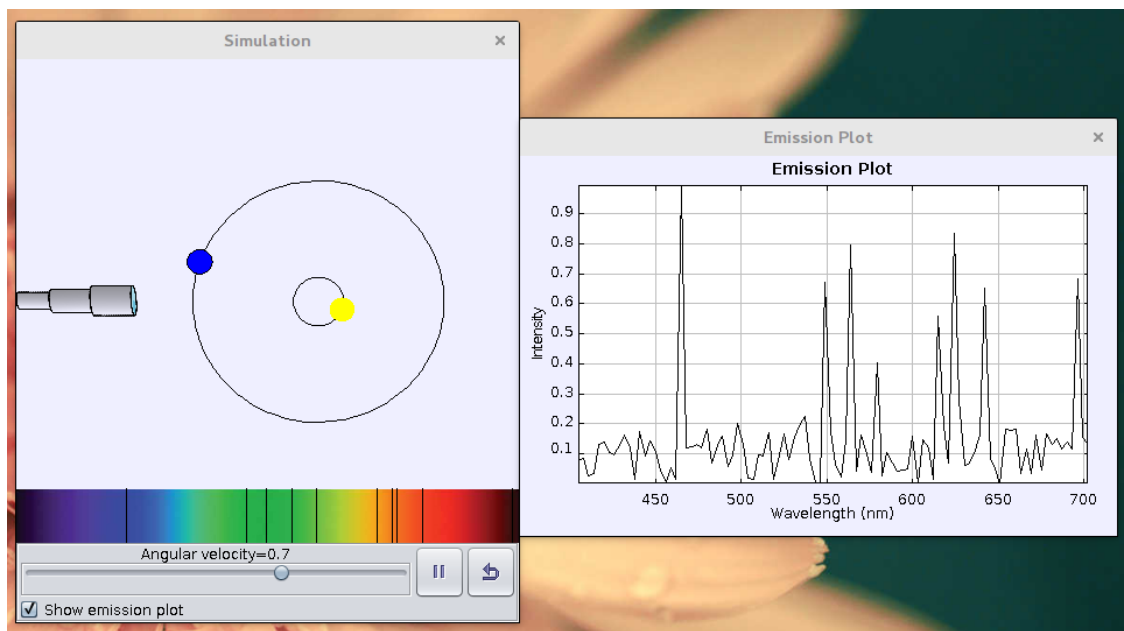


Figure 1: UI of the Doppler shift experiment